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(54) Head diagnosis apparatus and head diagnosis method for printer

(57) In a head diagnosis apparatus and the head diagnosis method for diagnosing the condition of a thermal head (1; 23), after measuring the resistance value of a plurality of heat generation resistive elements (93) arranged on a head surface of the thermal head, a change amount of the resistance value of each heat generation resistive element (93) is calculated on the basis of the resistance value of each heat generation resistive element (93) measured in the past and the resistance value of each heat generation resistive element (93) measured at the current time. An electrification state of each heat generation resistive element (93) is judged on the basis of the calculation result, and the thermal head (1; 23) is diagnosed to see whether it is good or bad in accordance with the determination result, thereby permitting the diagnosis on the condition of the thermal head (1; 23) before actually entering a printing stage.

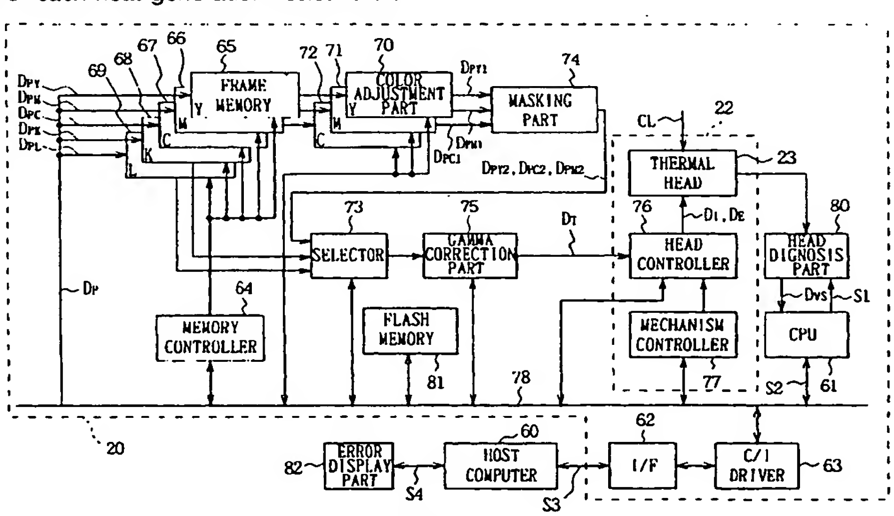

FIG. 7

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a head diagnosis apparatus and a head diagnosis method for printer, and more particularly, is applicable to a color printer with thermal recording system.

DESCRIPTION OF THE RELATED ART

[0002] A color printer of above-mentioned type comprises a thermal head having a plurality of heat generators arranged in line on its head surface perpendicular to the traveling direction of a printing paper. The thermal head is pressed against a platen with an ink ribbon and the printing paper interposed in between. In this state, the respective heat generators are selectively electrified on the basis of a predetermined image printing signal to generate heat from the selected heat generators which thermal-transfer a variety of pigments coated on the ink ribbon onto the surface of the printing paper. In this way a color image can be printed on the surface of the printing paper.

[0003] In the conventional color printer as mentioned above, however, when the thermal head suffers external damages or electrical trouble on its head surface during a thermal transfer operation, some of the plurality of heat generators arranged on the head surface of the thermal head remain open, when they should be closed. This prevents the current from flowing, or causes a short-circuit leaving the current to continuously flow.

[0004] In this case, on a printing paper after the thermal transfer operation leave white lines along its traveling direction, formed at corresponding positions where heat generators did not operate; or black lines along its traveling direction formed at corresponding positions to heat generators where current is always flowing to cause a continuous heat generated state.

[0005] Consequently, if an operator recognizes any printing errors on a printing paper, the operator needs to examine the condition of the thermal head, and accordingly replace the failed thermal head with a new one. However, when a large amount of printing is automatically performed using such a conventional color printer, any trouble in a thermal head would result in printing errors on a huge amount of printing papers. This causes producers to incur a larger scale of printing paper loss.

SUMMARY OF THE INVENTION

[0006] In view of the foregoing, an object of the invention is to provide a head diagnosis apparatus and a head diagnosis method for printer which are capable of efficiently preventing printing errors.

[0007] The foregoing object and other objects of the invention have been achieved by the provision of a head diagnosis apparatus for diagnosing the condition of a thermal head, which comprises: measuring means for measuring respectively the resistance value of a plurality of heat generation resistive elements arranged on a head surface of the thermal head; storage means for storing the resistance of each of the heat generation resistive elements measured by the measuring means; calculating means for calculating a change amount of the resistance of each of the heat generation resistive elements based on the resistance value of each of the heat generation resistive elements measured in the past which is stored in the storage means, and the resistance value of each of the heat generation resistive elements measured by the measuring means; and diagnosis means for judging the electrification state of each of the heat generation resistive elements based on the calculation result of the calculating means to diagnose the condition of the thermal head in accordance with the judgement.

[0008] As a result, it can be readily judged whether each heat generation resistive element is at present in a normal electrification state or is currently exhibiting an abnormal electrification state, or whether it is likely to fall into a fault in future, before actually entering the printing stage.

[0009] Also, in the present invention, a head diagnosis method for diagnosing the condition of a thermal transfer measures the resistance value of a plurality of heat generation resistive elements arranged on a head surface of the thermal head, and then calculates a change amount of the resistance value of each heat generation resistive element on the basis of the resistance value of each heat generation resistive element measured in the past and the resistance value of each heat generation resistive element measured at the current time to judge a electrification state of each heat generation resistive element on the basis of the calculation result, and to diagnose the condition of the thermal head in accordance with the judgement.

[0010] As a result, it can be readily judged whether each heat generation resistive element is currently in a normal electrification state or is currently exhibiting an abnormal electrification state, or whether it is likely to fall into a fault in future before actually entering the printing stage.

[0011] The nature, principle and utility of the invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings in which like parts are designated by like reference numerals or characters.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the accompanying drawings:

Fig 1 is a schematic plan view and cross-sectional view used for explaining the structure of a thermal

head;

Fig. 2 is a cross-sectional view illustrating the thermal head of Fig. 1 having a protective film suffering a flaw;

Fig. 3 is a cross-sectional view illustrating the thermal head of Fig. 1 having a protective film suffering thunderbolt;

Fig. 4 is a graph illustrating the relation between the resistance value of a heat generation resistive element and the time;

Fig. 5 is a schematic lateral view illustrating the structure of a card printer according to an embodiment;

Fig. 6 is a schematic view used for explaining an ink ribbon;

Fig. 7 is a block diagram illustrating the circuit configuration of a color image printing part;

Fig. 8 is a block diagram illustrating the internal configuration of a thermal head;

Fig. 9 is a block diagram illustrating the configuration of a head diagnosis part illustrated in Fig. 7;

Fig. 10 is a block diagram illustrating in detail the configuration of the head diagnosis part of Fig. 9;

Fig. 11 is a graph illustrating the relation between the resistance value of a heat generation resistive element and a voltage based on differential voltage data;

Fig. 12 is a flow chart used for explaining a head diagnosis processing procedure; and

Fig. 13 is a flow chart used for explaining a head diagnosis processing procedure.

DETAILED DESCRIPTION OF THE EMBODIMENT

[0013] Preferred embodiments of this invention will be described with reference to the accompanying drawings:

[0014] Generally, as illustrated in Fig. 1A, a thermal head 1 has a plurality of heat generators 2A to 2N (N is a predetermined number) arranged in line on a head surface 1A perpendicularly to the traveling direction of a printing paper (not shown). Each of the heat generators 2A to 2N has a heat generation resistive element 5 on a protrusion of a glass layer 4 laminated on a ceramic substrate 3 as illustrated in a cross-sectional view taken along a line A-A' across the head surface 1A in Fig. 1B. The heat generation resistive element 5, together with electrodes 6 formed at one end and the other end thereof, is overlaid by a protective film 7 made of a glass material.

[0015] If relatively hard dust or the like gets in between the head surface 1A of the thermal head 1 and a platen (not shown) to damage the heat generators 2A to 2N on the head surface 1A, the protective film 7 of the heat generators 2A to 2N corresponding to the damaged portion is likely to suffer a flaw 7A as illustrated in Fig. 2. In this event, since stress concentrates on the flaw 7A in the protective film 7, the heat generation resistive element 5 changes its resistance value. When any of the heat generators 2A to 2N is gravely damaged, an associated heat generation resistive element 5 is opened to break a current flow, resulting in a white line drawn on a printing paper along its traveling direction.

[0016] On the other hand, if static electricity is generated on the head surface 1A of the thermal head 1 during a printing operation to cause a thunderbolt, a pinhole 7B is likely to be formed through the protective film 7 of the heat generators 2A to 2N, which was stuck by the thunderbolt, as illustrated in Fig. 3. In this event, since moisture, ions or the like can get in or out through the pinhole 7B of the protective film 7, the heat generation resistive element 5 changes its resistance value. If a stronger thunderbolt is generated, a current always flows into the heat generation resistive element 5, resulting in a black line drawn on a printing paper along its traveling direction.

[0017] Here, Fig. 4 illustrates the relation between the resistance value of the heat generation resistive element 5 and the time change. In Fig. 4, a characteristic curve F1 of the heat generation resistive element 5 has a characteristic in which the resistance value of the heat generation resistive element 5 is R_0 at time T_0, once decreases over time, and then gradually increases.

[0018] Actually, if any of the heat generators 2A to 2N flaws at time T_1 to open its heat generation resistive element 5, the resistance value of the heat generation resistive element 5 slightly increases and causes a slightly upward shift of the characteristic curve F1, resulting in a characteristic curve F1A. On the other hand, if a thunderbolt is generated in the heat generators 2A to 2N at time T_1 to short-circuit a heat generation resistive element 5, the resistance value of the heat generation resistive element 5 slightly lowers and causes a slightly downward shift of the characteristic curve F1, resulting in a characteristic curve F1B.

[0019] It is therefore possible to judge whether or not a heat generation resistive element 5 exhibits an abnormal electrification state by detecting an increasing or decreasing resistance value of the heat generation resistive element 5 to consequently diagnose the condition of the thermal head 1.

(2) General Configuration of Card Printer

[0020] In Fig. 5, a card printer, to which the present invention is applied, is generally designated by reference numeral 10. A card material 13 inserted into the card printer from a card insertion slot 11A of a housing 11 through cleaning rollers 12A, 12B is carried by the card carrier 14 along a carrying path CR.

[0021] The card material 13 employed in this embodiment conforms to the so-called International Organization for Standardization (ISO) standard. Specifically, the card material 13 has a magnetic stripe formed on one side along a longitudinal edge, and an Integrated Circuit (IC) memory embedded in the other side at a predeter-

mined position near a front end of the card material 13.

[0022] The card carrier 14 is composed of first and second carrying sections 14A, 14B disposed on front and back sides of a platen 15 along the carrying path CR. The first and second carrying sections 14A, 14B are provided with four pairs of carrying rollers 16A to 19A and 16B to 19B, respectively, which are mounted on axes for any rotation along the carrying path CR at predetermined intervals.

[0023] The upper carrying rollers 16A to 19A are rotated in the same direction in association with each other according to the rotation of a driving motor (not shown), while the lower carrying rollers 16B to 19B are kept in contact with the corresponding upper carrying rollers 16A to 19A, so that the lower carrying rollers 16B to 19B are rotated in the direction opposite to the rotation of the upper carrying rollers 16A to 19A. With the structure as mentioned, the card material 13, inserted between the upper and lower carrying rollers 16A to 19A and 16B to 19B, is carried forward or backward along the carrying path CR in accordance with the rotation of the upper carrying rollers 16A to 19A.

[0024] A color image printing part 20 is disposed at a predetermined position opposing the platen 15 above the card carrier 14. In the color image printing part 20, a head holding mechanism 22 including a head part 21 is extended in a direction in which a thermal head 23 supported at a leading end of the head part 21 is pressed against the platen 15, and is retracted in a direction in which the thermal head 23 is brought away from the platen 15.

[0025] Actually, the head holding mechanism 22 is constructed of a cam 25 which rotates on a driving shaft 24 of a head motor (not shown), and a link mechanism engaged with the cam 25 and including a shifter member 28, a connecting member 29 and a supporting member 30 with a rotating shafts 26, 27 as fixed links.

[0026] Thus, in this head holding mechanism 22, the link mechanism 26 to 30 engaged with the cam 25 is extended in response to the driving of the head motor in a printing mode in order to press the thermal head 23 against the platen 15. After terminating the printing mode, the link mechanism 26 to 30 engaged with the cam 25 is retracted in response to the driving of head motor in order to bring the thermal head 23 away from the platen 15.

[0027] In an image printing mode, the color image printing part 20 drives the head holding mechanism 22 to press the thermal head 23 against the platen 15 with a roll-shaped ink ribbon 33, supported by a supply reel 31 and a wind-up reel 32, and a card material 13 positioned on the platen 15 interposed in between. Subsequently, the thermal head 23 is heated in this state based on a predetermined image printing signal to thermal-transfer the ink on the ink ribbon 33 onto one side of the card material 13.

[0028] In this case, the roll-shaped ink ribbon 33 is accommodated in a ribbon cassette 34. The ribbon cassette 34 is loaded capable of being removed between the color image printing part 20 and the platen 15 through a cassette insertion slot (not shown) formed on a side wall of the housing 11.

[0029] The ink ribbon 33 includes color pigments of yellow Y, magenta M, cyan C and black K, each coated over at a predetermined length thereon as a pigment for one piece of the card material 13, followed by a film-like sheet L, as illustrated in Fig. 6. Further, a predetermined mark (not shown) is impressed at the head position for each page of the ink ribbon 33 in order that the head position of the ink ribbon 33 can be located by detecting the mark by an optical sensor (not shown) disposed on a running path of the ink ribbon 33.

[0030] The supply real 31 is provided with a torque limiter (not shown) for applying a predetermined torque during rotation, so that the ink ribbon 33 is always applied with a back tension. Further, an optical sensor (not shown) is disposed near the supply real 31 for detecting the diameter of the rolled ink ribbon 33. And by detecting the tension of the ink ribbon 33, the winding state of the wind-up reel 32 can be controlled.

[0031] Below the carrying path CR in the second carrier 14B, a magnetic recording/reproducing part 40 is disposed. A magnetic head 41 is exposed on the carrying path CR so as to be positioned side by side with the lower carrying roller 18B and contacted the upper carrying roller 18A only during recording and reproduction. And the magnetic head 41 is concealed below the carrying path CR other than during recording and reproduction.

[0032] Thus, the magnetic recording/reproducing part 40 records information based on a predetermined recording signal on magnetic stripes (not shown) formed on one side of the card material 13, with the magnetic head 41 exposed on the carrying path CR. Subsequently, the magnetic recording/reproducing part 40 reproduces the recorded information to judge whether or not any recording errors are found on the magnetic stripes.

[0033] Optical sensors 42, 43, 44 of photo-interrupter type are disposed on front and back sides of the first carrying section 14A and in front of the second carrying section 14B in order that the presence or absence of the card material 13 carried along the carrying path CR is detected.

[0034] Behind the second carrier 14B and near a card discharge slot 11B of the housing 11, a rotary carrier 45 is disposed along the carrying path CR. The rotary carrier 45 has a rotary mechanism 46 supported on a rotating shaft 47 on which it can rotate in a direction indicated by an arrow r or in the opposite direction. The rotary mechanism 46 includes a first pair of flipper rollers 48A, 48B and a second pair of flipper rollers 49A, 49B. And each pair is capable of any rotation keeping a symmetrical position with the rotation shaft 47 in between.

[0035] The flipper rollers 48A, 49A on an upper side

each rotate in the same direction in conjunction with the rotation of the driving motors (not shown). The flipper rollers 48B, 49B on a lower side are each pressed against the corresponding flipper rollers 48a, 49A on the upper side, and rotate in the opposite direction to the rotation of the flipper rollers 48A, 49A. With the structure as mentioned, the card material 13 inserted between the first pair of flipper rollers 48A, 48B and/or between the second pair of flipper rollers 49A, 49B is carried forward or backward on the carrier path CR according to the rotation of the flipper rollers 48A, 49A on the upper side.

[0036] In this way, the rotary carrier 45 holds the card material 13 carried from the second carrying section 14B in the rotary mechanism 46, and rotates the rotary mechanism 46 together with the card material 13 held therein over a predetermined angular distance in the direction indicated by the arrow r or in the opposite direction as required to position the rotary mechanism 46, so that the card material 13 is delivered in a predetermined direction determined by positioning.

[0037] An IC recording/reproducing part 50 is disposed near the rotary carrier 45. As the card material 13 delivered from the rotary carrier 45 is inserted into an insertion slot 50A of the IC recording/reproducing part 50, each terminal of an IC memory (not shown) disposed on the other side of the card material 13 is brought into contact with an interface connector (not shown). As a result, the IC recording/reproducing part 50 records information based on a predetermined recording signal, and then reproduces the recorded information to judge whether or not any recording errors are found in the IC memory.

[0038] An unacceptable card tray 51 is disposed near the rotary carrier 45. A card material 13, which has been judgeded that recording errors have been found in the magnetic recording/reproducing part 40 or in the IC recording/reproducing part 50, is discharged from the rotary carrier 45 through an inlet slot 51A to the unacceptable card tray 52.

[0039] Conversely, the rotary carrier 45 delivers a card material 13, which has been determined that no recording errors have been found in the magnetic recording/reproducing part 40 or in the IC recording/reproducing part 50, to an external card tray (not shown) through a card discharge slot 11B of the housing 11.

[0040] In addition, a first optical sensor 52 and a second optical sensor 53, both of a photo-interrupter type, are disposed outside the first pair of flipper rollers 48A, 48B and outside the second pair of flipper rollers 49A, 49B (i.e., both in the centrifugal direction of the rotating shaft 47), respectively, for detecting the presence or absence of the card material 13 sent thereto along the carrying path CR.

[0041] For reference, in this card printer 10, the card carrier 14, the color image printing part 20, the magnetic recording/reproducing part 40, the rotary carrier 45 and the IC recording/reproducing part 50 are each driven in predetermined states in accordance with the control of a CPU 61 which responds to instructions from a host computer 60 (Fig. 7), later described.

(3) Printing Processing in Color Image Printing Part

[0042] Fig. 7 illustrates the circuit configuration of the color image printing part 20. As predetermined image printing data D_P is supplied from a host computer 60 through an interface (I/F) 62 and a Computer Interface (C/I) driver 63, a memory controller 64 writes a one-frame portion of the image printing data D_{CP} into corresponding frame memories 65 to 69 as color image printing data D_{PY} (yellow Y), D_{PM} (magenta M), D_{PC} (cyan C) and D_{PK} (black K), corresponding to the respective colors, and laminate data P_{DL} (film-like sheet L) in accordance with the control of the CPU 61.

[0043] Next, the memory controller 64 reads the color image printing data D_{PY}, D_{PM}, D_{PC}, D_{PK} and the laminate data D_{PL} from the respective frame memories 65 to 69 at predetermined timing in accordance with the control of the CPU 61. Then the color image printing data D_{PY}, D_{PM}, D_{PC} are transmitted to color adjustment parts 70 to 72, respectively, and the color image printing data D_{PK} and the laminate data D_{PL} are transmitted to respective input terminals of a selector 73.

[0044] The color adjustment parts 70 to 72, which are provided with a color conversion table (not shown) having standard image printing characteristics for each color, perform color adjustment for each color in accordance with an adjustment curve before and after color matching processing, and transmit resulting color image printing data D_{PY1}, D_{PM1}, D_{PC1} to a masking part 74.

[0045] The masking part 74 separates unnecessary data from the supplied color image printing data D_{PY1}, D_{PM1}, D_{PC1} and transmits resulting color image printing data D_{PY2}, D_{PM2}, D_{PC2} to the other input terminal of the selector 73.

[0046] The selector 73 sequentially transmits data selected as required from the respective color image printing data D_{PY2}, D_{PM2}, D_{PC}, D_{PK} and the laminate data D_{PL}, supplied thereto, based on the control of the CPU 61 to a gamma correction part 75. The gamma correction part 75 performs a color-strength electrification time conversion with a predetermined heat correction coefficient which has been set on the basis of the control of the CPU 61, and supplies a head controller 76 with print image data D_T resulting from the conversion.

[0047] The head controller 76, which is disposed in the head holding mechanism 22, converts the print image data D_T to a current signal D_I which is then provided to the thermal head 23. As a result, a plurality of heat generation resistive elements arranged on a head surface (not shown) of the thermal head 23 are heated in accordance with the current signal D_I. Consequently, the color image printing part 20 can heat the head surface of the thermal head 23 based on the image printing

data D_P and print a desired color image in accordance with the image print data D_P based on the heated head on one or the other side of the card material 13.

[0048] The CPU 61 can move the thermal head 23 in the head part 22 closer to or away from the platen 15 by controlling the driving of mechanical controller 77 including the aforementioned cam 25 and the link mechanism 26 to 30, described in Fig. 5. The CPU 61 also sends control instructions to respective circuits through a bus 78.

[0049] In addition to the configuration described above, the color image printing part 20 is provided with a head diagnosis part 80 between the CPU 61 and the thermal head 23. The head diagnosis part 80 sequentially measures the resistance value of each heat generation resistive element one by one for a plurality of heat generators (not shown) disposed on the head surface of the thermal head 23 in order to permit judgement as to whether or not the resistance value of each heat generation resistive element is normal based on the results of the measurements.

[0050] The CPU 61 first sends a switching signal S1 to the head diagnosis part 80 to selectively switch the head diagnosis part 80 to a printing mode or a head diagnosis mode. In this event, for selecting the head diagnosis mode, the head controller 76 sends electrification setting data D_E to the thermal head 23 for sequentially measuring one by one the resistance value of the heat generation resistive elements corresponding to the respective heat generators of the thermal head 23 in accordance with the control of the CPU 61.

[0051] As illustrated in Fig. 8, the thermal head 23 has a plurality of heat generators $23H_1$ to $23H_N$ (N is for example equal to 640) on the head surface. The heat generators $23H_1$ to $23H_N$ are connected by a latch circuit 90 to a plurality of registers $91R_1$ to $91R_N$, which constitute a serial-type shift register.

[0052] Image printing data D_I are orderly stored one by one in the plurality of registers $91R_1$ to $91R_N$ in synchronization with a clock CL inputted thereto. When the image printing data D_I have been stored in all of the registers $91R_1$ to $91R_N$, all outputs of the $91R_1$ to $91R_N$ are applied in parallel to the latch circuit 90.

[0053] Respective heat generators $23H_1$ to $23H_N$ are connected to a common power supply 94 through heat generation resistive elements $93R_1$ to $93R_N$ which basically comprise transistors $92Q_1$ to $92Q_N$, respectively, each of which has a collector connected to a load resistor. All emitters are connected to a common terminal (not shown) in the head diagnosis part 80. And bases are connected to each output stage of the latch circuit 90 through load resistors $95R_1$ to $95R_N$, respectively.

[0054] The latch circuit 90, upon receiving the electrification setting data D_E supplied from the head controller 76, sequentially electrifies and connects one by one between a heat generator $23H_I$ (I is an arbitrary number satisfying $1 \leqq I \leqq N$) and a corresponding register $91R_I$, thereby sequentially turning on a transistor $92Q_I$ in the heat generator $23H_I$. This causes a voltage of the power supply 94 to be applied to each heat generator $23H_I$, and a collector-emitter current to flow through a corresponding heat generation resistive element $93R_I$ into the head diagnosis part 80.

[0055] The head diagnosis part 80 has a configuration based on an operational amplifier 100, as illustrated in Fig. 9, which has one input terminal connected to the thermal head 23, to a drain of a power Metal Oxide Semiconductor (MOS) Field Effect Transistor (FET) 101 and to a load resistor 102R, and the other input terminal is connected to a reference voltage source 103.

[0056] A source of the power MOS FET 101, the load resistor 102R and the reference voltage source 103 are connected to a ground GND. The power MOS FET 101 is used as a switching circuit which turns on or off in response to "H" or "L" level of the switching signal S1 supplied from the CPU 61 to the gate thereof.

[0057] More specifically, in the printing mode, when the CPU 61 supplies the power MOS FET 101 with the switching signal S1 at "H" level to cause the power MOS FET 101 to turn on, current supplied from each heat generator $23H_I$ flows into the ground GND as a drain-source current of the power MOS FET 101. For this reason, the current supplied from each heat generator $23H_I$ does not flow through an intermediate connection point P1 between the one input terminal of the operational amplifier 100 and the load resistor 102R.

[0058] In the head diagnosis mode, on the other hand, when the CPU 61 supplies the power MOS FET 101 with the switching signal S1 at "L" level to cause the power MOS FET 101 to turn OFF, the current supplied from each heat generator $23H_I$ does not flow through the drain-source of the power MOS FET 101 but flows through the intermediate connection point P1 into the one input terminal of the operational amplifier 100 as well as through the load resistor 102R to the ground GND.

[0059] Responsively, the operational amplifier 100 calculates the difference in potential between the one input terminal and the other input terminal, subsequently converts the differential voltage to a digital form through an analog-to-digital (A/D) converter circuit 104, and sends the digital product to the CPU 61 as differential voltage data D_{VS}.

[0060] The operational amplifier 100 is composed of a differential amplifier circuit 110 as a basic component, and a current regulating circuit 111 connected thereto, as illustrated in Fig. 10. The differential amplifier circuit 110 has a pair of PNP transistors Q1, Q2, which have their bases connected to the power supply 94 through a heat generation resistive element $93R_I$ of the heat generator $23H_I$ and a load resistor 113R which has the same resistance value as the heat generation resistive element $93R_I$, respectively.

[0061] An intermediate connection point P2 between the base of the transistor Q2 and the load resistor 113R is connected to an end of a voltage dividing resistor

114R which has the same resistance value as the load resistor 102R and has the other end connected to the ground GND. The reference voltage source 103 mentioned above in connection with Fig. 9 is actually composed of the resistors 113R, 114R connected in series between the power supply 94 and the ground GND, and the differential amplifier 110 connected to the intermediate connection point P2 between the resistors 113R and 114R.

[0062] The transistor Q1 has a collector connected to the ground GND, while the transistor Q2 has a collector connected through a voltage dividing resistor 115R to the ground GND. An intermediate connection point P3 between the collector of the transistor Q2 and the resistor 115R is connected to the A/D converter circuit 104.

[0063] The current regulating circuit 111 has a pair of PNP transistors Q3, Q4, which have their emitters connected commonly to the power supply 94 through load resistors 116R, 117R. Bases of the transistors Q3, Q4 are connected to one end of a capacitor C1, the other end of which is connected to the power supply 94, and also connected through a load resistor 118R to the ground GND. Thus, the current regulating circuit 111 is configured in order that the same current as that flowing into the transistor Q4 flows into the transistor Q3.

[0064] The transistor Q3 has its collector connected through load resistors 119R, 120R commonly to emitters of the transistors Q1, Q2 in the differential amplifier circuit 110, respectively.

[0065] In the configuration illustrated in Fig. 10, the power MOS FET 101 is in OFF state in the head diagnosis mode, wherein a currents flows into the intermediate connection point P1 from the power supply 94 through the heat generation resistive element $93R_I$ of the heat generator part $23H_I$, thereby causing a potential difference V_I to be generated at the intermediate connection point P1, as expressed by the following expression (1):

$$V_I = \frac{r_M}{(r_I + R_M)} \times V_M \qquad (1)$$

where a voltage value of the power supply 94 is V_H; the resistance value of the heat generation resistive element $93R_I$ is r_I; and the resistance value of the load resistor 102R is r_M.

[0066] In this event, if the resistance value r_I of the heat generation resistive element $93R_I$ falls within a predetermined set standard range, the intermediate connection points P1, P2 both have the same potential difference, so that a differential voltage value outputted from the differential amplifier circuit 110 through the intermediate connection point P3 is applied as it is to the A/D converter circuit 104.

[0067] Here, if the resistance value r_I of the heat generation resistive element $93R_I$ is higher than the set standard range to reduce the potential at the intermediate connection point P1, a current flowing into the base of the transistor Q1 decreases, causing an emitter-collector current of the transistor Q1 to decrease. At this point, since a current flowing from the current regulating circuit 111 is regular, a reduced portion of the emitter-collector current of the transistor Q1 is added to an emitter-collector current of the transistor Q2 to increase the same. As a result, the potential difference at the intermediate connection point P3 is increased and applied to the A/D converter circuit 104.

[0068] On the other hand, if the resistance value r_I of the heat generation resistive element $93R_I$ is lower than the set standard range to increase the potential at the intermediate connection point P1, a current flowing into the base of the transistor Q1 increases, causing the emitter-collector current of the transistor Q1 to increase. At this point, since a current flowing from the current regulating circuit 111 is regular, the increased emitter-collector current of the transistor Q1 is subtracted from the emitter-collector current of the transistor Q2 to reduce the same. As a result, the potential difference at the intermediate connection point P3 is reduced and applied to the A/D converter circuit 104.

[0069] In this way, when the thermal head 23 is applied with the electrification setting data D_E, a current flows through the heat generation resistive element $93R_I$ disposed in each heat generator $23H_I$ within the thermal head 23 to generate a drop voltage V_I across the heat generation resistive element $93R_I$. The head diagnosis part 80 calculates a difference between the voltage V_I and the voltage V_M of the reference voltage source 103 and converts the calculated difference to a digital form to produce differential voltage data D_{VS} which is sent to the CPU 61.

[0070] The CPU 61 also contains a predetermined conversion table (not shown), such that the resistance value r_I of the heat generation resistive element $93R_I$ corresponding to the differential voltage data D_{VS} can be retrieved from the conversion table based on a characteristic curve F2 which represents the resistance value r_I of the heat generation resistive element $93R_I$ in proportion to the voltage of the differential voltage data D_{VS}, as illustrated in Fig. 11.

[0071] Consequently, the CPU 61 sequentially retrieves from the conversion table the resistance value r_I of the heat generation resistive element $93R_I$ corresponding to the differential voltage data D_{VS} sequentially supplied from the head diagnosis part 80 based on the differential voltage data D_{VS}, and then stores the retrieved resistance value r_I in a flash memory 81.

[0072] The flash memory 81 previously stores initial resistance value (the resistance value measured when they were manufactured) r_{0I} of all the heat generation resistive elements $93R_I$, and also stores the resistance value r_I of all the heat generation resistive elements $93R_I$ measured in the previous head diagnosis mode.

[0073] Here, if the CPU 61 judges that the resistance value r_I of a heat generation resistive element $93R_I$ cor-

responding to a voltage of differential voltage data D_{VS} supplied from the head diagnosis part 80 is out of a predetermined range with respect to the characteristic curve F2 illustrated in Fig. 11, the CPU 61 sends a printing reference signal S2 to the host computer 60 through the C/I driver 63 and the interface 62 as required (Fig. 7).

[0074] The host computer 60, upon receipt of the printing reference signal S2, judges whether or not a heat generator $23H_I$ within the thermal head 23 exhibiting an abnormal electrification state actually is used for an image printing area based on image printing data D_P within an image to be printed, and sends a diagnosis notification signal S3 in accordance with the result of the judgement to the CPU 61 through the interface and the C/I driver.

[0075] In this event, the host computer 60 sends to an error display part 82 an error signal S4 indicating that the thermal head 23 has failed, when the result of the judgement is negative, thereby causing the error display part 82 to display on its display screen that the thermal head 23 has failed.

(4) Processing Procedure for Diagnosing Thermal Head

[0076] The CPU 61 in the color image printing part 20 executes a head diagnosis processing procedure RT1 illustrated in Figs. 12, 13 based on the control of the host computer 60, to diagnose whether or not each of heat generators $23H_1$ to $23H_N$, arranged on the surface of the thermal head 23, exhibits an abnormal electrification state by sequentially measuring one by one the resistance value of the heat generation resistive elements $93R_1$ to $93R_N$ within the respective heat generators $23H_1$ to $23H_N$.

[0077] First, the CPU 61 enters the head diagnosis processing procedure RT1 illustrated in Fig. 12 from step SP0 in accordance with the control of the host computer 60, before starting a printing operation or after ending a printing operation, that is, when not in the printing mode. At subsequent step SP1, the CPU 61 turns off the power MOS FET 101 to set the head diagnosis mode. Then, the CPU 61 proceeds to step SP2, where the CPU 61 sequentially electrifies one by one the heat generation resistive elements $93R_1$ to $93R_N$ in the plurality of heat generators $23H_1$ to $23H_N$ of the thermal head 23.

[0078] Subsequently, the CPU 61 proceeds to step SP3, where for one of the heat generators $23H_I$ ($1 \leq I \leq N$), a current flowing into the intermediate connection point P1 from the power supply 94 through the head generation resistive element $93R_I$ and a current flowing from the reference voltage source 103 are applied to one input terminal and the other input terminal, respectively, of the operational amplifier 100 in the head diagnosis unit 80 illustrated in Fig. 9, to force the operational amplifier 100 to calculate the difference between the voltage V_I at the intermediate connection point P1 and the voltage V_M of the reference voltage source 103. Then, the CPU 61 receives the differential voltage.

[0079] Next, at step SP4, the CPU 61 retrieves the resistance value r_I of the heat generation resistive element $93R_I$ corresponding to the received differential voltage in accordance with the predetermined conversion table (not shown) stored therein.

[0080] At step SP5, the CPU 61 determines whether or not the retrieved resistance value r_I of the heat generation resistive element $93R_I$ is within a predetermined range with respect to the characteristic curve F2 in the aforementioned Fig. 11.

[0081] If a negative result is returned at step SP5, this means that the heat generation resistive element $93R_I$ is in an open state or in a short-circuited state, in which case the CPU 61 proceeds to step SP6, where it further judges whether or not the resistance value r_I is higher than the predetermined range with respect to the characteristic curve F2.

[0082] If an affirmative result is returned at step SP6, this means that the heat generation resistive element $93R_I$ is in a short-circuited state, in which case the CPU 61 proceeds to step SP7 (Fig. 13), later described, where it notifies the host computer 60 of the fact that the heat generation resistive element $93R_I$ exhibits an abnormal electrification state.

[0083] On the other hand, if a negative result is returned at step SP6, this means that the heat generation resistive element $93R_I$ is in an open state, in which case the CPU 61 proceeds to step SP8, where the CPU 61 forces the host computer 60 to judge whether or not the heat generation resistive element $93R_I$ is actually a heat generation resistive element R_I of a heat generator $23H_I$ falling into an image printing area based on image printing data D_P within an image to be printed.

[0084] If an affirmative result is returned at step SP8, this means that the heat generator $23H_I$ does affect the contents to be printed on a card material 13, in which case the CPU 61 proceeds to step SP7, where it notifies the host computer 60 of the fact that the heat generation resistive element $93R_I$ exhibits an abnormal electrification state, as mentioned above.

[0085] On the other hand, if a negative result is returned at step SP8, the CPU 61 determines that the heat generation resistive element $93R_I$ is in a normal electrification state since the contents to be printed on the card material 13 will not be affected by the heat generation resistive element $93R_I$ even if it is in an open state. Then, the CPU 61 proceeds to step SP9 (Fig. 13), later described.

[0086] At step SP5, if an affirmative result is returned, this means that the resistance value of the heat generation resistive element $93R_I$ retrieved from the conversion table is within the predetermined range with respect to the characteristic curve F2, in which case the CPU 61 proceeds to step SP10, where it reads from the flash memory 81 the resistance value r_I' of the heat generation resistive element $93R_I$ measured in the preced-

ing head diagnosis mode, and an initial resistance value r_{0I} of the heat generation resistive element $93R_I$ at the time of manufacturing.

[0087] Subsequently, at step SP11, the CPU 61 calculates a changing rate A_I of the resistance value r_I of the heat generation resistive element $93R_I$ measured at this time to the resistance value r_I' of the heat generation resistive element $93R_I$ measured at the preceding time as represented by the following expression (2):

$$A_I = \frac{|r_I - r_I'|}{r_I'}. \qquad (2)$$

[0088] Subsequently, the CPU 61 proceeds to step SP12, where it determines whether or not the difference between the changing rate A_I and a changing rate A_I' which is calculated in the preceding head diagnosis mode is equal to or less than a predetermined value. If a negative result is returned, this means that it is highly likely that the heat generation resistive element $93R_I$ falls into an abnormal electrification state. The CPU 61 proceeds to step SP13 illustrated in Fig. 13, where it judges whether the changing rate A_I exceeds a predetermined value which is set as an abnormal changing rate.

[0089] If a negative result is returned at step SP13, this means that the difference between the changing rate A_I and the previously calculated changing rate A_I' is equal to or more than the predetermined value and equal to or less than the predetermined value above which an abnormal changing rate is identified. At this point, the CPU 61 proceeds to step SP14, where it sets a flag representative of a warning (hereinafter referred to as the "warning flag") in the flash memory 81 in order to register that the heat generation resistive element $93R_I$ is less likely to fall into an abnormal electrification state at this time.

[0090] Subsequently, the CPU 61 proceeds to step SP15, where it judges whether or not a warning flag has been set in the flash memory 81 for the heat generation resistive element $93R_I$ in the preceding head diagnosis mode.

[0091] If an affirmative result is returned at step SP15, this means that the heat generation resistive element $93R_I$ has been likely to fall into an abnormal electrification state not only at the preceding time but also at the present time. At this point, the CPU 61 proceeds to step SP7, where it judges in the foregoing manner that the heat generation resistive element $93R_I$ has been in an abnormal electrification state, and notifies the host computer 60 of this fact.

[0092] On the other hand, if a negative result is returned at step SP15, this means that the heat generation resistive element $93R_I$ could exhibit for the first time an abnormal electrification state in the current head diagnosis mode, in which case the CPU 61 proceeds to step SP9.

[0093] Turning back to step SP12 illustrated in Fig. 12, if an affirmative result is returned, this means that the difference between the changing rate A_I and a changing rate A_I' which is calculated in the preceding head diagnosis mode of the heat generation resistive element 93 R_I is equal to or less than the predetermined value, and accordingly the heat generation resistive element $93R_I$ exhibits a normal electrification state, in which case the CPU 61 proceeds to step SP16 (Fig. 13), where it overwrites the current resistance value r_I and the changing rate A_I of the heat generation resistive element $93R_I$ in the flash memory 81.

[0094] Subsequently, even if the changing rate A_I is within the predetermined range, the thermal head 23 is likely to fall into a fault if the resistance value r_I of the heat generation resistive element $93R_I$ takes a value out of the predetermined range with respect to the initial resistance r_{0I}. Thus, the CPU 61 proceeds to step SP17, where it judges whether or not the difference between the resistance value r_I and the initial resistance value r_{0I} is equal to or less than a predetermined value.

[0095] If a negative result is returned at step SP17, the CPU 61 proceeds to step SP7, where it notifies the host computer 60 of the fact that the heat generation resistive element $93R_I$ exhibits an abnormal electrification state, similarly to the above. As a result, the host computer 60, upon receipt of the notification from the CPU 61, displays on the display screen of the error display part 82 that the thermal head 23 is faulty or likely to fall into a fault.

[0096] On the other hand, if an affirmative result is returned at step SP17, this means that the heat generation resistive element $93R_I$ is in a normal electrification state, in which case the CPU 61 proceeds to step SP9, where it judges whether the heat generation resistive element $93R_I$ is the last electrified heat generation resistive element $93R_N$.

[0097] If an affirmative result is returned at step SP9, the CPU 61 judges that the diagnosis has been completed for all the heat generation resistive elements $93R_1$ to $93R_N$ as to whether or not they exhibit an abnormal electrification state, and then proceeds immediately to step SP18 to terminate the head diagnosis processing procedure RT1.

[0098] On the other hand, if a negative result is returned at step SP9, the CPU 61 again returns to step SP3, where it executes the processing from step SP3 to step SP17 for the next electrified heat generation resistive element $93R_{I+1}$ as described above, and repeats this processing until an affirmative result is returned at step SP9.

(5) Operation and Effect of Embodiment

[0099] In the configuration described above, in the color image printing part 20 in the card printer 10, the heat generation resistive elements $93R_1$ to $93R_N$ in the plurality of heat generators $23H_1$ to $23H_N$ arranged on

the surface of the thermal head 23 are sequentially electrified one by one, and the resistance value of the heat generation resistive elements $93R_1$ to $93R_N$ is measured respectively to determine whether or not each of the heat generation resistive elements $93R_I$ ($1 \leqq I \leqq N$) is open or short-circuited based on the resistance value r_I thereof during the head diagnosis mode.

[0100] If the respective heat generation resistive elements $93R_I$ are not open or short-circuited, then the changing rate A_I of the heat generation resistive element $93R_I$ is calculated on the basis of the resistance value r_I' of the heat generation resistive element $93R_I$ measured at the preceding time and the resistance value r_I corresponding thereto measured at the current time. It can be determined on the basis of each changing rate A_I whether or not the associated heat generation resistive element $93R_I$ is currently in a normal electrification state or is likely to suffer a fault in future, before actually entering a printing stage.

[0101] In this event, even if each heat generation resistive element $93R_I$ is determined to be normal at present, it can be judged whether or not the thermal head 23 is faulty or is likely to fall into a fault in accordance of the difference between the changing rate A_I of the heat generation resistive element R_I and the previously calculated changing rate A_I' of the heat generation resistive element $93R_I'$ corresponding thereto.

[0102] When it is determined as above that the thermal head 23 is faulty or is likely to fall into a fault, this fact is displayed on the error display unit 82, thereby allowing the operator to readily and visually confirm the condition of the thermal head 23 before entering a printing stage.

[0103] Even when some heat generation resistive elements $93R_X$ (X is an arbitrary number) of the plurality of heat generation resistive elements $93R_1$ to $93R_N$ are opened, the heat generation resistive elements $93R_X$ are treated as normal if the heat generation resistive elements $93R_X$ are not actually heat generation resistive elements which correspond to an image printing area based on image printing data D_P within an image to be printed, because they do not affect the contents printed on a card material 13. In this way, when the heat generation resistive elements $93R_X$ only are opened among the plurality of heat generation resistive elements $93R_1$ to $93R_N$, the thermal head 23 need not be replaced with a new one, thereby making it possible to further improve the use efficiency of the thermal head 23.

[0104] According to the foregoing configuration, in the color image printing part 20 of the card printer 10, the heat generation resistive elements $93R_1$ to $93R_N$ within the plurality of heat generators $23H_1$ to $23H_N$ arranged on the surface of the thermal head 23 are sequentially electrified one by one before starting a printing operation or after ending a printing operation. Then, the changing rate A_I is calculated on the basis of the previously measured resistance value r_I' of each heat generation resistive element $93R_I$ ($1 \leqq I \leqq N$) and the corresponding resistance value r_I measured at the current time. Then, a electrification state of the corresponding heat generation resistive element $93R_I$ is determined on the· based on the changing rate A_I, thereby making it possible to previously judge the condition of the thermal head 23 before entering an actual printing stage. Consequently, printing errors can be efficiently prevented.

(5) Other Embodiments

[0105] In the foregoing embodiment, when a heat generation resistive element $93R_I$ exhibits an abnormal electrification state, the CPU 61 judges the host computer 60 of this fact as the predetermined error processing, so that the host computer 60 forces the error display part 82 to display on its display screen that the thermal head 23 is faulty or is likely to fall into a fault. The present invention is not limited thereto. Alternatively, when a heat generation resistive element $93R_I$ exhibits an abnormal electrification state, the CPU 61 can bring the color image printing part 20 into a printing stop state instead of or in addition to notifying the host computer 60 of the fact. In this case, even if the color image printing part 20 is switched to a printing mode, it is possible to obviate printing errors on a card material 13 since the color image printing part 20 is in the printing stop state.

[0106] Also, in the foregoing embodiment, when a certain heat generation resistive element $93R_X$ (X is an arbitrary number) among the plurality of heat generation resistive elements $93R_1$ to $93R_N$ is opened, the CPU 61 sends a printing reference signal S2 to the host computer 60 so that the host computer 60 judges whether or not the heat generation resistive element $93R_X$ is actually a heat generation resistive element which corresponds to an image printing area based on image printing data D_P within an image to be printed. The present invention, however, is not limited thereto. Alternatively, the color image printing part 20 illustrated in Fig. 7 can be provided therein with a frame memory (not shown) for storing an image based on the image printing data D_P so that the CPU 61 makes the above-mentioned determination based on the image printing data D_P read from the frame memory, without intervention of the host computer 60.

[0107] Further, in the foregoing embodiment, when the resistance value of each heat generation resistive element $93R_1$ to $93R_N$ are measured, the CPU 61 uses a predetermined conversion table to retrieve the resistance value of each heat generation resistive element $93R_I$ ($1 \leqq I \leqq N$) corresponding to differential voltage data D_{VS} supplied from the head diagnosis part 80. The present invention, however, is not limited thereto. Alternatively, the CPU 61 does inverse calculating differential voltage data D_{VS} outputted from the head diagnosis part 30 to derive the resistance value of each heat generation resistive element $93R_I$. In essence, a wide vari-

ety of other configurations can be applied as measuring means as long as it can measure the resistance value of each electrified heat generation resistive element $93R_I$.

[0108] Further, in the foregoing embodiment, the CPU 61, serving as calculation means, calculates the change rate A_I for the resistance value of each heat generation resistive element 93RI based on the resistance value r_I' of each heat generation resistive element $93R_I$ previously measured in the head diagnosis part 80 and the resistance value r_I of each heat generation resistive element $93R_I$ measured at this time. The present invention, however, is not limited thereto. Alternatively, a wide variety of other configurations can be applied as the calculating means.

[0109] Further, in the foregoing embodiment, the CPU 61, serving as diagnosis means, relies on the change rate A_I for the resistance value r_I of each heat generation resistive element $93R_I$ to jugde a electrification state of the corresponding heat generation resistive element $93R_I$, and with the result of the judgement judges the condition of the thermal head 23 in accordance. The present invention, however, is not limited thereto. In essence, the host computer 60 can be used as the diagnosis means, or a wide variety of other configurations can be applied as the diagnosis means, as long as it can readily judge, before actually entering a printing stage, whether or not each heat generation resistive element 93RI is currently in a normal electrification state, or whether or not a fault is currently occurring, or whether or not a fault is likely to occur in future.

[0110] Further, in the foregoing embodiment, the flash memory 81 is used as storage means for storing the resistance value r_I of each heat generation resistive element $93R_I$ measured in the head diagnosis part 80. The present invention, however, is not limited thereto, but a variety of configurations can be applied including, for example, electrically erasable programmable read only memory (EEPROM), static random access memory (static RAM), or the like.

[0111] Further, while in the foregoing embodiment, the card material 13 in accordance with the ISO standard is used as a printing medium, the present invention is not limited thereto. Alternatively, a card material in accordance with Japan Industrial Standard (JIS) can be used. Further alternatively, the present invention can also be applied to a variety of card materials, which do not have an IC card and/or magnetic stripes.

[0112] According to the present invention as described above, a head diagnosis apparatus for diagnosing the condition of a thermal head comprises: measuring means for measuring respectively the resistance value of a plurality of heat generation resistive elements arranged on a head surface of the thermal head; storage means for storing the resistance value of each of the heat generation resistive elements measured by the measuring means; calculating means for calculating a change amount of the resistance value of each heat generation resistive element based on the resistance value of each heat generation resistive element measured in the past, stored in the storage means, and the resistance value of each heat generation resistive element measured by the measuring means; and diagnosis means for judging a electrification state of each heat generation resistive elements based on the calculation result of the calculating means to diagnose the condition of the thermal head in accordance with the judgement result; thereby making it possible to diagnose the condition of the thermal head before entering a printing stage. Consequently, it is possible to realize a head diagnosis apparatus which is capable of efficiently preventing printing errors.

[0113] Also, in the present invention, a thermal head diagnosis method for diagnosing the condition of a thermal head first measures respectively the resistance value of a plurality of heat generation resistive elements arranged on a head surface of the thermal head, and then calculates a change amount of the resistance value of each heat generation resistive element based on the resistance value of each heat generation resistive element measured in the past, and the resistance value of each heat generation resistive elements measured at the current time to determine a electrification state of each heat generation resistive element based on the calculation result for diagnosing the condition of the thermal head in accordance with the judgement result, thereby making it possible to diagnose the condition of the thermal head before entering a printing stage. Consequently, it is possible to realize a head diagnosis method which is capable of efficiently preventing printing errors.

[0114] While there has been described in connection with the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be aimed, therefore, to cover in the appended claims all such changes and modifications as fall within the true spirit and scope of the invention.

Claims

1. A head diagnosis apparatus for diagnosing the condition of a thermal head (1; 23) comprising:

    measuring means for measuring respectively the resistance value of a plurality of heat generation resistive elements arranged on a head surface of said thermal head;
    storage means (90) for storing said resistance value of each of said heat generation resistive elements measured by said measuring means;
    calculating means (100) for calculating a change amount of the resistance value of each of said heat generation resistive elements based on the resistance value of each of said heat generation resistive elements measured in the past, stored in said storage means, and

the resistance value of each of said heat generation resistive elements measured by said measuring means; and

diagnosis means (80) for judging a electrification state of each of said heat generation resistive elements based on the calculation result of said calculating means to diagnose the condition of said thermal head in accordance with said judgement.

2. The head diagnosis apparatus according to claim 1, wherein said diagnosis means executes predetermined error processing when diagnosing that said thermal head is faulty or is highly likely to fall into a fault based on the calculation result of said calculating means.

3. The head diagnosis apparatus according to claim 1, wherein said diagnosis means does not execute predetermined error processing when said heat generation resistive element at a position which does not affect printing image exhibits an abnormal electrification state based on the calculation result of said calculating means.

4. A thermal head diagnosis method for diagnosing the condition of a thermal head (1; 23) comprising:

a first step (SP4) of measuring respectively the resistance value of a plurality of heat generation resistive elements (93) arranged on a head surface of said thermal head;

a second step (SP11) of calculating a change amount of the resistance value of each of said heat generation resistive elements based on the resistance value of each of said heat generation resistive elements measured in the past, and the resistance value of each of said heat generation resistive elements at a current time; and

a third step (SP12) of judging an electrification state of each of said heat generation resistive elements based on the calculation result to diagnose the condition of said thermal head in accordance with said judgement.

5. The head diagnosis method according to claim 4 wherein said third step includes the step of executing predetermined error processing when diagnosing that said thermal head is faulty or is highly likely to fall into a fault based on the calculation result.

6. The head diagnosis method according to claim 4 wherein said third step does not execute predetermined error processing when said heat generation resistive element at a position which does not affect printing an image exhibits an abnormal electrification state based on the calculation result.

7. A printer having a thermal head comprising

diagnosis means for diagnosing the condition of said thermal head.

8. A printer (10) having a head diagnosis function of diagnosing the condition of said thermal head (1; 23) comprising:

measuring means for measuring respectively the resistance value of a plurality of heat generation resistive elements (93) arranged on a head surface of said thermal head;

storage means (90) for storing said resistance value of each of said heat generation resistive elements measured by said measuring means;

calculating means (100) for calculating a change amount of the resistance value of each of said heat generation resistive elements based on the resistance value of each of said heat generation resistive elements measured in the past, stored in said storage means, and the resistance value of each of said heat generation resistive elements measured by said measuring means; and

diagnosis means (80) for judging a electrification state of each of said heat generation resistive elements based on the calculation result of said calculating means to diagnose the condition of said thermal head in accordance with said judgement.

9. The printer having a head diagnosis function according to claim 8, wherein said diagnosis means executes predetermined error processing when diagnosing that said thermal head is faulty or is highly likely to fall into a fault based on the calculation result of said calculating means.

10. The printer having a head diagnosis function according to claim 8, wherein said diagnosis means does not execute predetermined error processing when said heat generation resistive element at a position which does not affect printing image exhibits an abnormal electrification state based on the calculation result of said calculating means.

11. A diagnosis method of diagnosing a printer (10) having a thermal head (1; 23) comprising

head diagnosing means (80) for diagnosing the

condition of said thermal head.

12. A printer head diagnosis method having a head diagnosis function of diagnosing the condition of a thermal head (1; 23) comprising:

    a first step (SP4) of measuring respectively the resistance value of a plurality of heat generation resistive elements arranged on a head surface of said thermal head;
    a second step (SP11) of calculating a change amount of the resistance value of each of said heat generation resistive elements based on the resistance value of each of said heat generation resistive elements measured in the past, and the resistance value of each of said heat generation resistive elements at a current time; and
    a third step (SP12) of judging a electrification state of each of said heat generation resistive elements based on the calculation result to diagnose the condition of said thermal head in accordance with said judgement.

13. The printer head diagnosis method according to claim 12 wherein
said third step includes the step of executing predetermined error processing when diagnosing that said thermal head is faulty or is highly likely to fall into a fault based on the calculation result.

14. The printer head diagnosis method according to claim 12 wherein
said third step does not execute predetermined error processing when said heat generation resistive element at a position which does not affect printing image exhibits an abnormal electrification state based on the calculation result.

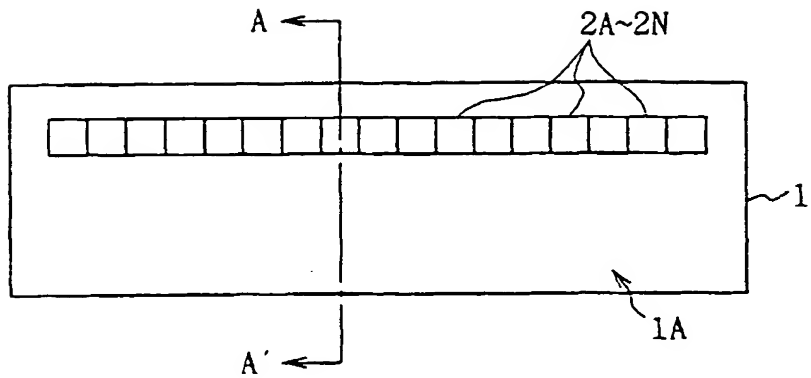


FIG. 1A

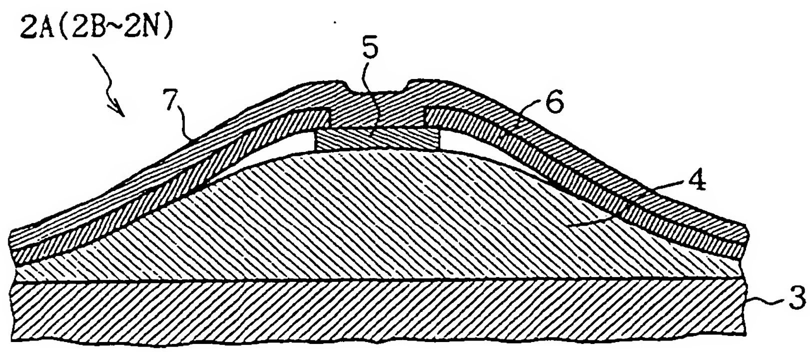


FIG. 1B

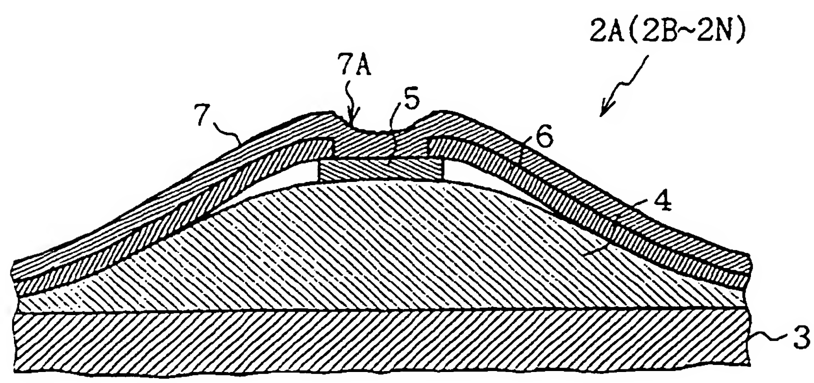


FIG. 2

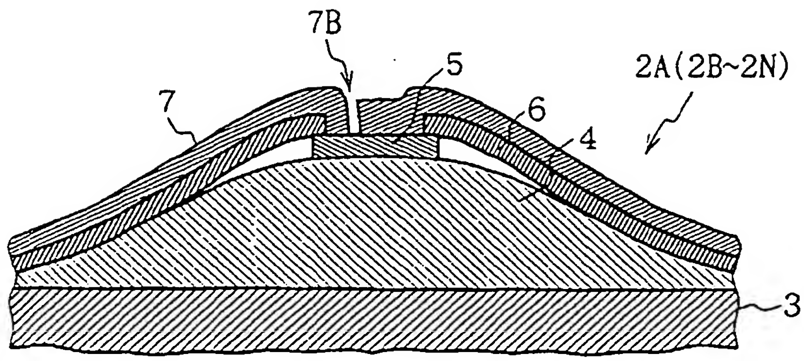


FIG. 3

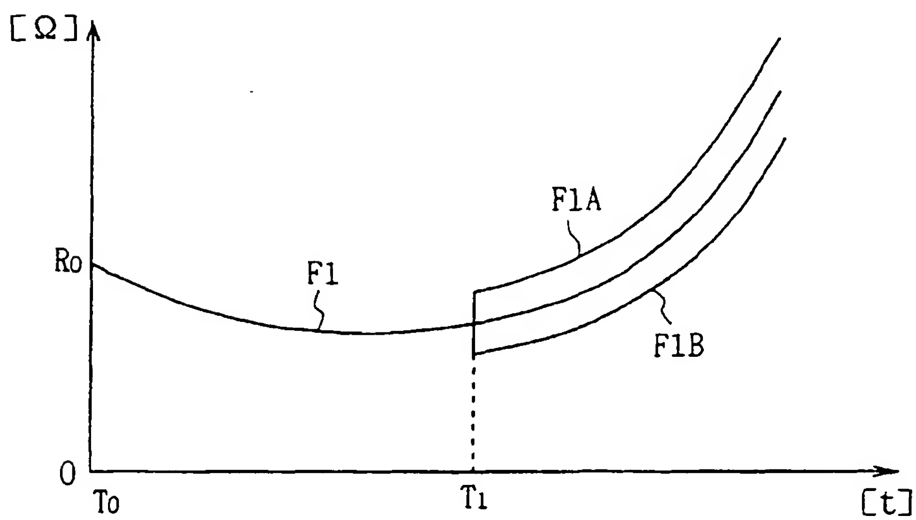


FIG. 4

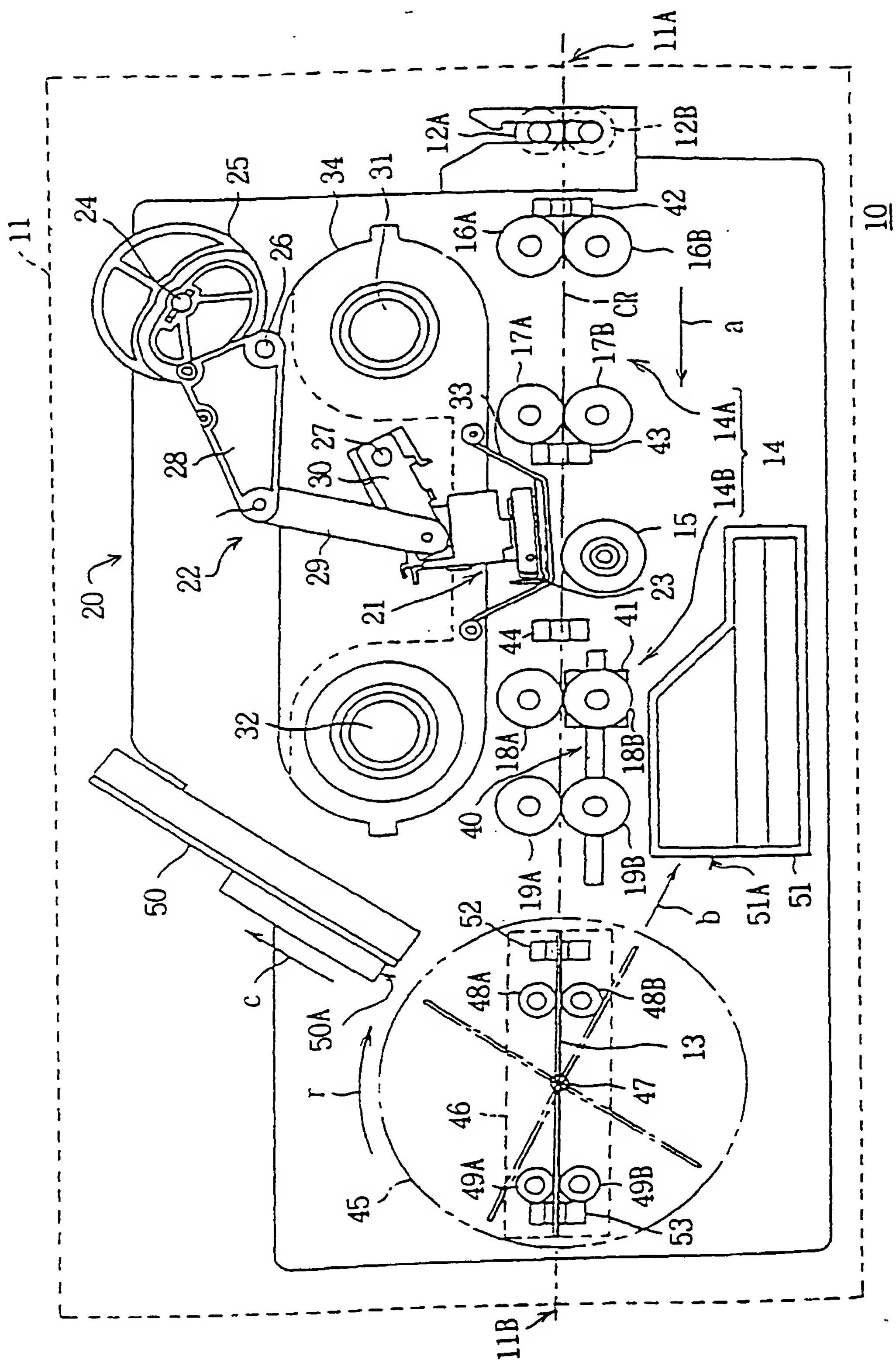

11A
12A
12B
11
24
25
34
31
26
16A
42
16B
10
CR
a
17A
17B
33
27
30
28
43
14A
14
14B
15
22
29
21
23
20
44
41
32
18A
18B
40
19A
19B
50
52
b
51A
51
c
50A
48A
48B
13
r
47
46
45
49A
49B
53
11B

FIG. 5

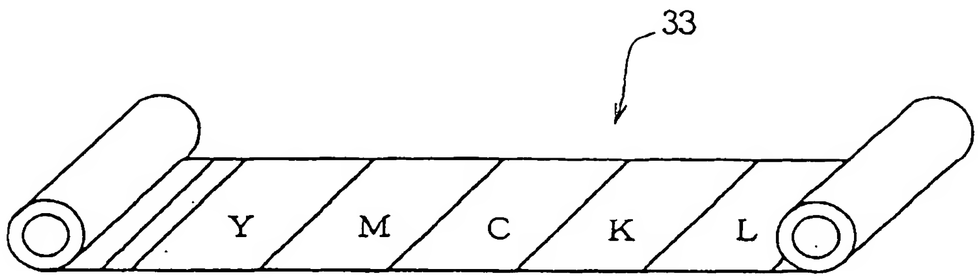

33
Y
M
C
K
L

FIG. 6

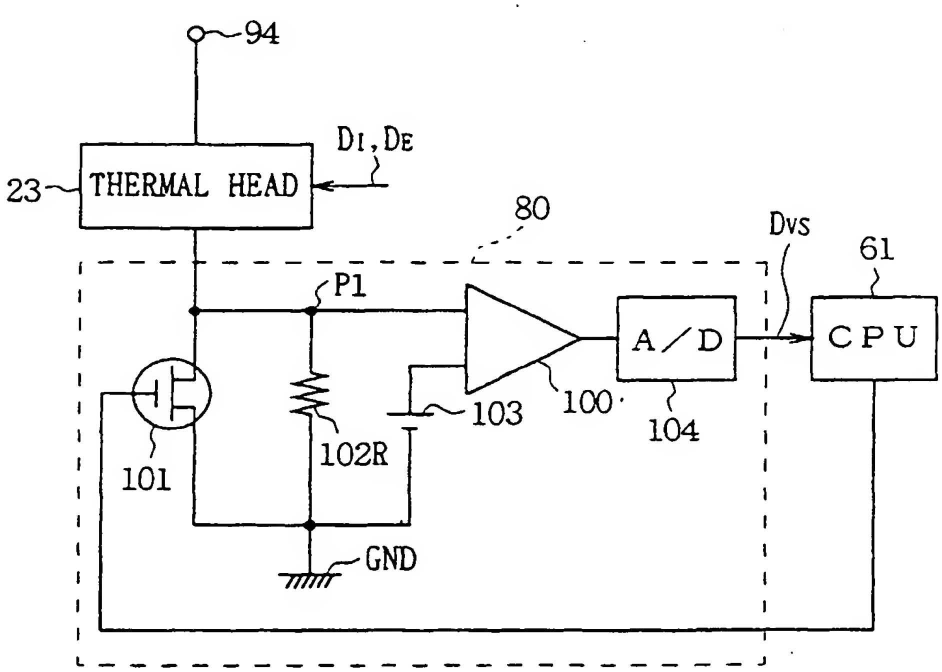
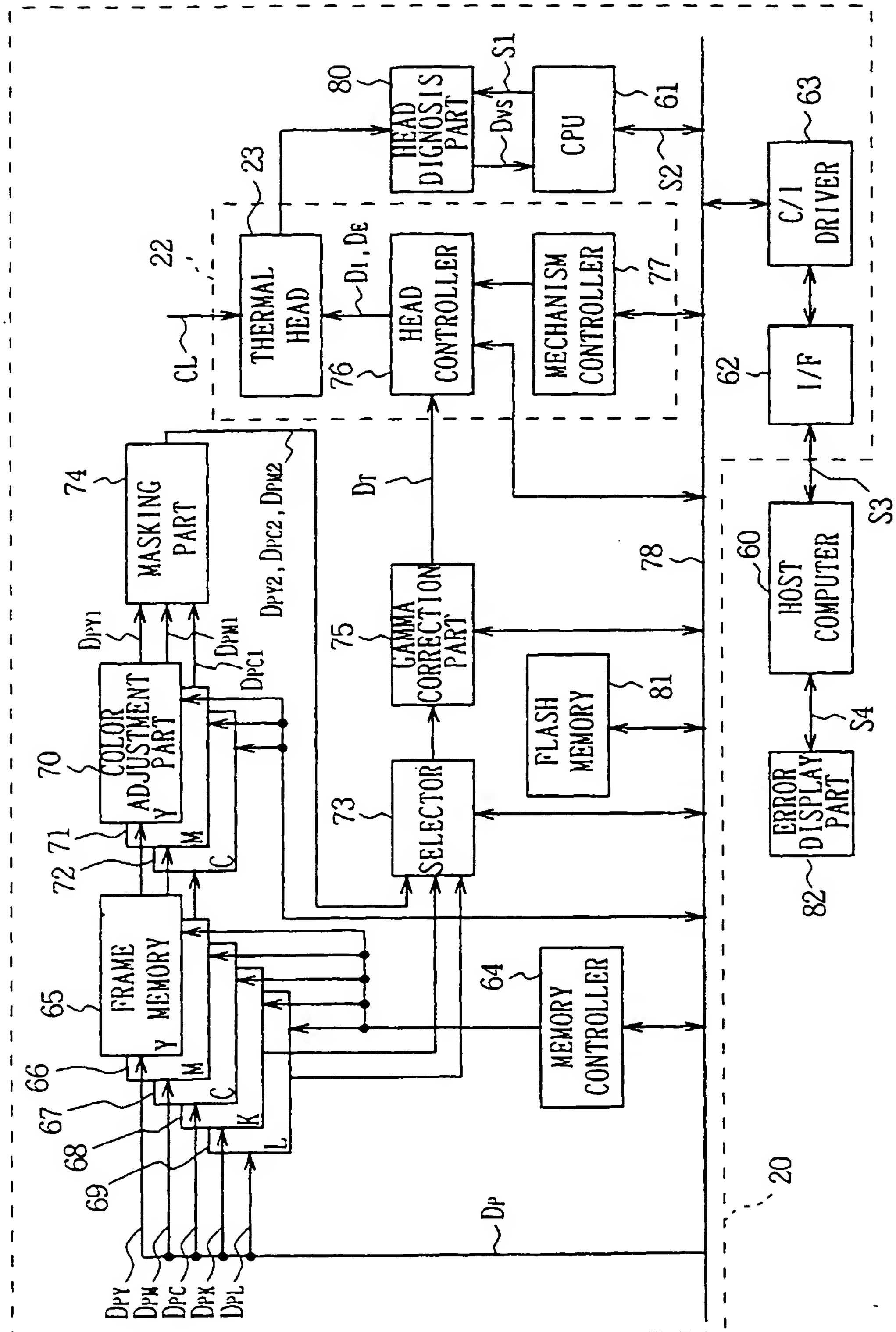

94
DI, DE
23
THERMAL HEAD
80
Dvs
61
P1
A/D
CPU
103
100
104
102R
101
GND

FIG. 9


THERMAL HEAD
HEAD CONTROLLER
MECHANISM CONTROLLER
HEAD DIGNOSIS PART
CPU
C/I DRIVER
I/F
HOST COMPUTER
ERROR DISPLAY PART
MASKING PART
COLOR ADJUSTMENT PART
GAMMA CORRECTION PART
FLASH MEMORY
SELECTOR
FRAME MEMORY
MEMORY CONTROLLER
Y
M
C
K
L
CL
D_I, D_E
D_{VS}
D_T
D_P
D_{PY1}
D_{PM1}
D_{PC1}
$D_{PY2}, D_{PC2}, D_{PM2}$
D_{PY}
D_{PM}
D_{PC}
D_{PK}
D_{PL}
S1
S2
S3
S4
20
22
23
60
61
62
63
64
65
66
67
68
69
70
71
72
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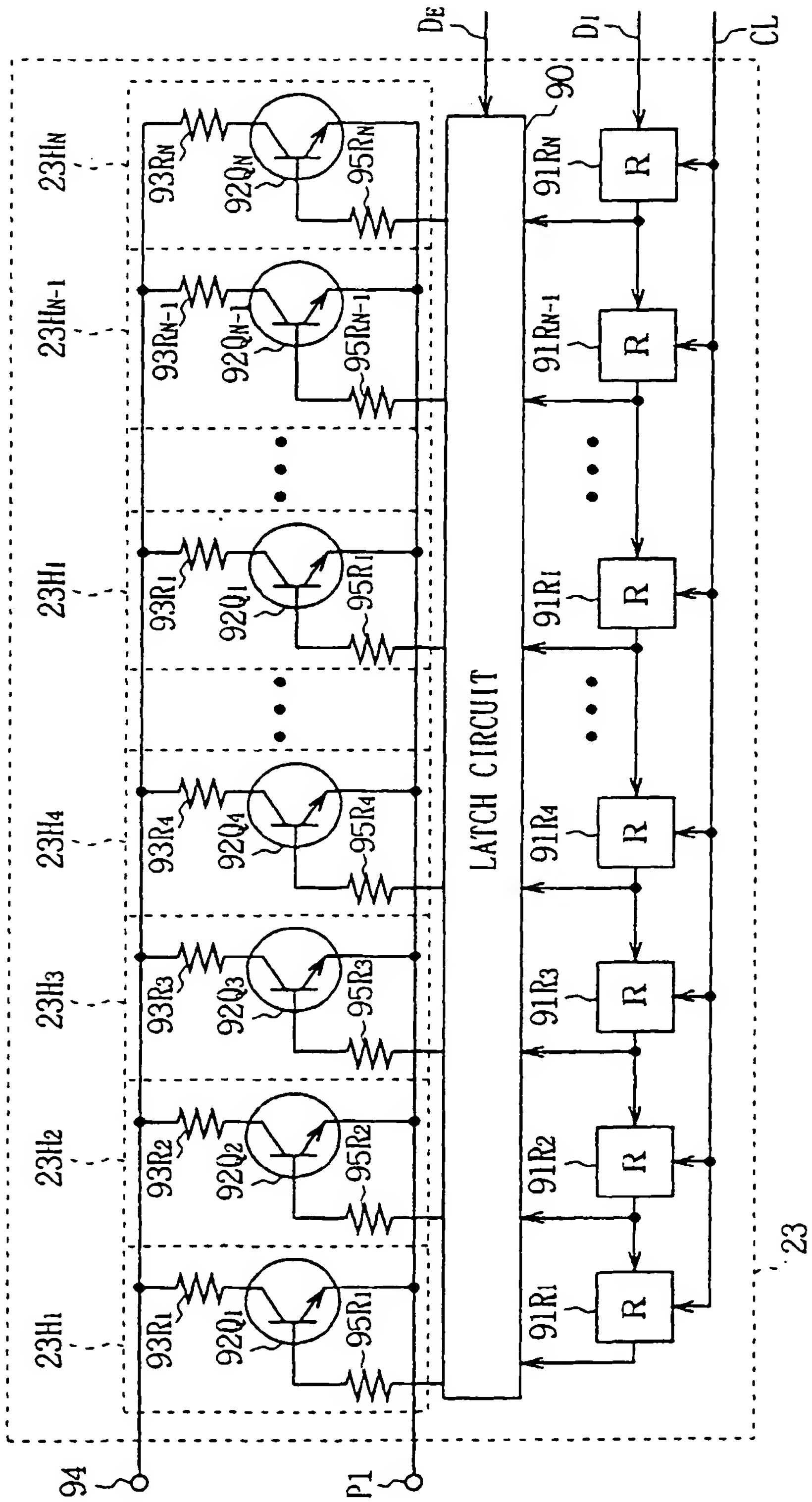
78
80
81
82

FIG. 7



LATCH CIRCUIT
R
DE
DI
CL
90
23
94
P1
23H1
23H2
23H3
23H4
23HI
23HN-1
23HN
93R1
93R2
93R3
93R4
93RI
93RN-1
93RN
92Q1
92Q2
92Q3
92Q4
92QI
92QN-1
92QN
95R1
95R2
95R3
95R4
95RI
95RN-1
95RN
91R1
91R2
91R3
91R4
91RI
91RN-1
91RN

FIG. 8

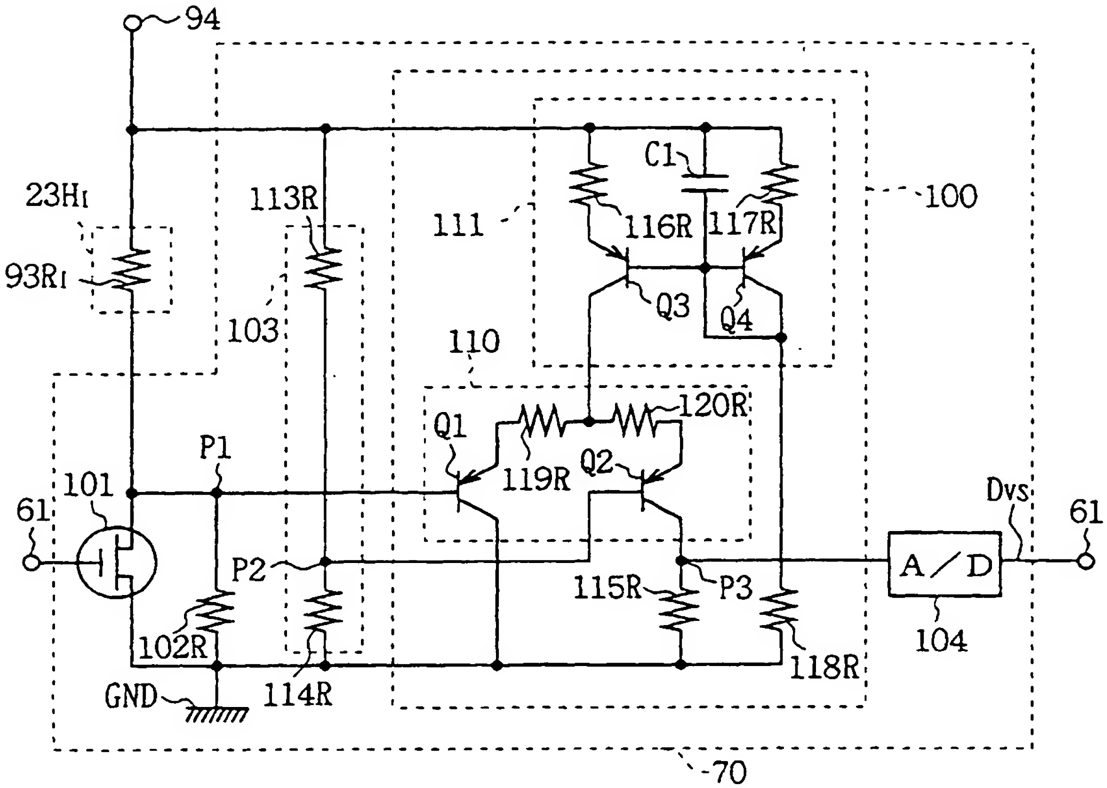

94
23HI
93RI
113R
103
111
100
C1
116R
117R
Q3
Q4
110
120R
Q1
119R
Q2
P1
101
61
Dvs
61
P2
115R
P3
A／D
102R
114R
118R
104
GND
70

FIG. 10

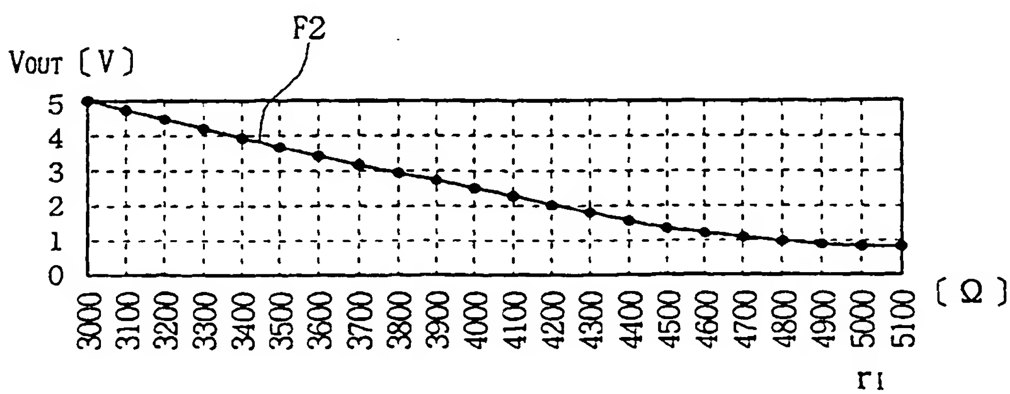

F2
VOUT [V]
5
4
3
2
1
0
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
5100
[Ω]
rI

FIG. 11

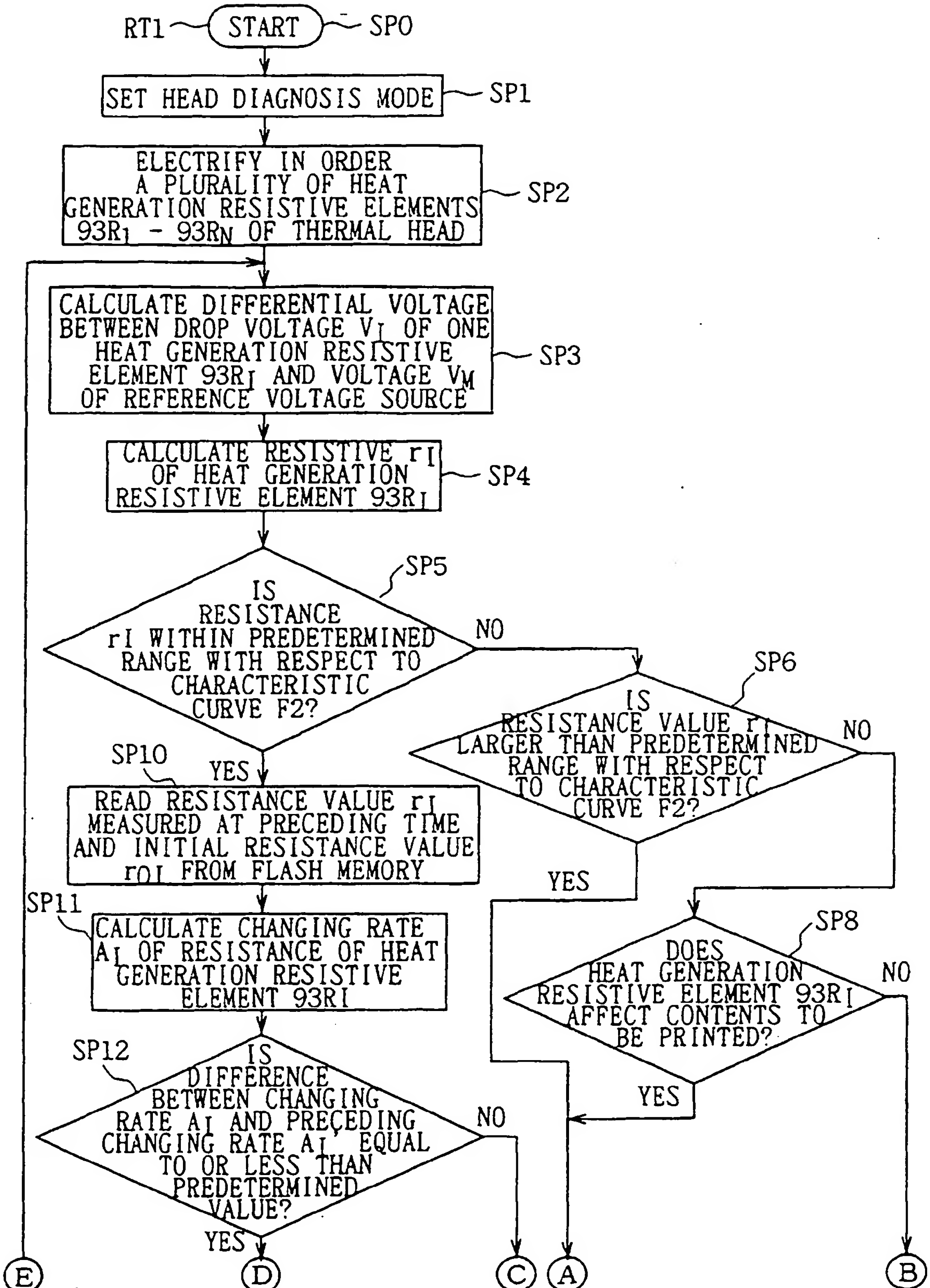

RT1
START
SP0
SET HEAD DIAGNOSIS MODE
SP1
ELECTRIFY IN ORDER A PLURALITY OF HEAT GENERATION RESISTIVE ELEMENTS 93R1 - 93RN OF THERMAL HEAD
SP2
CALCULATE DIFFERENTIAL VOLTAGE BETWEEN DROP VOLTAGE VI OF ONE HEAT GENERATION RESISTIVE ELEMENT 93RI AND VOLTAGE VM OF REFERENCE VOLTAGE SOURCE
SP3
CALCULATE RESISTIVE rI OF HEAT GENERATION RESISTIVE ELEMENT 93RI
SP4
SP5
IS RESISTANCE rI WITHIN PREDETERMINED RANGE WITH RESPECT TO CHARACTERISTIC CURVE F2?
NO
SP6
IS RESISTANCE VALUE rI LARGER THAN PREDETERMINED RANGE WITH RESPECT TO CHARACTERISTIC CURVE F2?
NO
SP10
YES
READ RESISTANCE VALUE rI MEASURED AT PRECEDING TIME AND INITIAL RESISTANCE VALUE r0I FROM FLASH MEMORY
YES
SP11
CALCULATE CHANGING RATE AI OF RESISTANCE OF HEAT GENERATION RESISTIVE ELEMENT 93RI
SP8
DOES HEAT GENERATION RESISTIVE ELEMENT 93RI AFFECT CONTENTS TO BE PRINTED?
NO
SP12
IS DIFFERENCE BETWEEN CHANGING RATE AI AND PRECEDING CHANGING RATE AI' EQUAL TO OR LESS THAN PREDETERMINED VALUE?
NO
YES
YES
E
D
C
A
B

FIG. 12

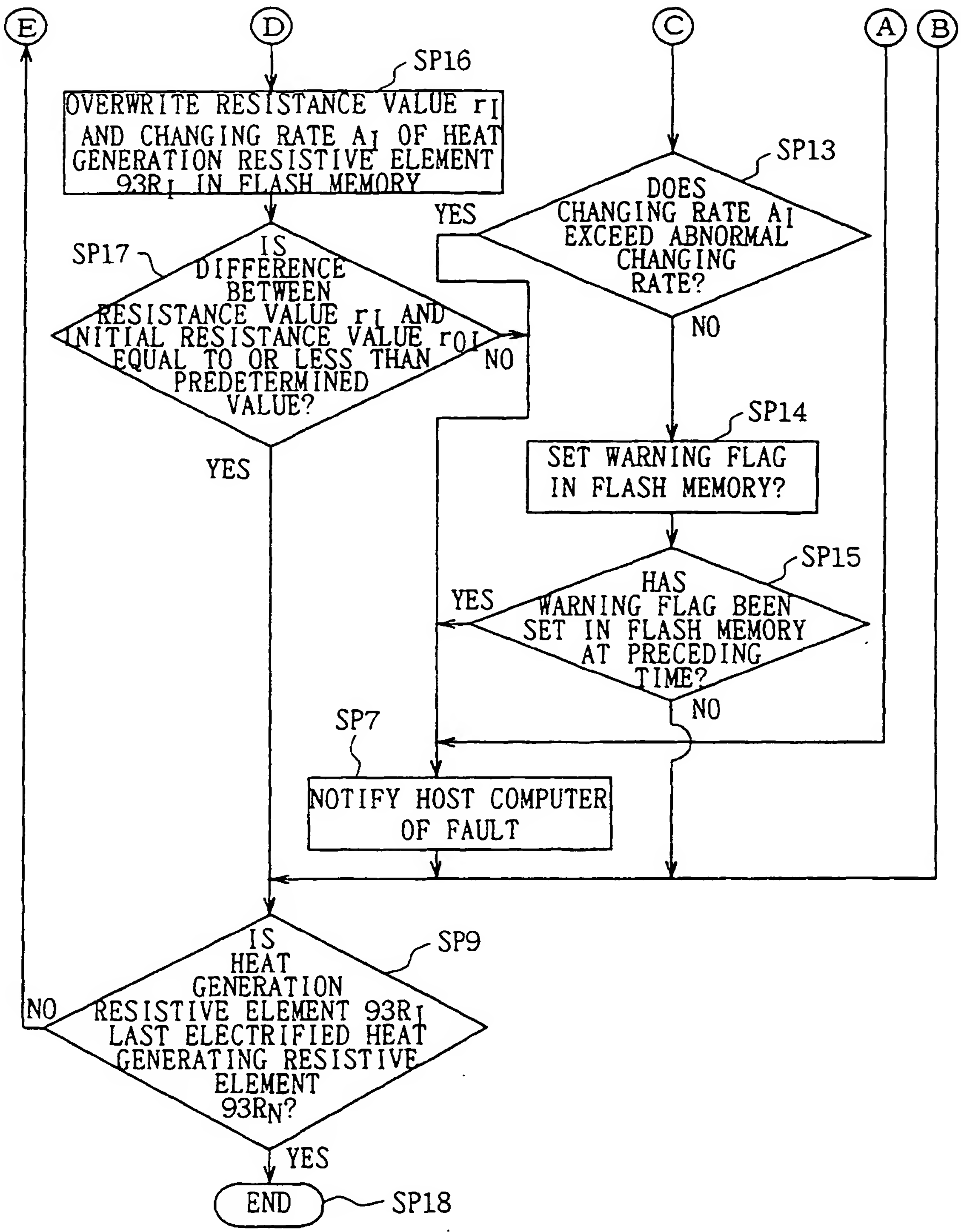

E
D
C
A
B
SP16
OVERWRITE RESISTANCE VALUE rI AND CHANGING RATE AI OF HEAT GENERATION RESISTIVE ELEMENT 93RI IN FLASH MEMORY
SP13
DOES CHANGING RATE AI EXCEED ABNORMAL CHANGING RATE?
YES
NO
SP17
IS DIFFERENCE BETWEEN RESISTANCE VALUE rI AND INITIAL RESISTANCE VALUE r0I EQUAL TO OR LESS THAN PREDETERMINED VALUE?
NO
YES
SP14
SET WARNING FLAG IN FLASH MEMORY?
SP15
HAS WARNING FLAG BEEN SET IN FLASH MEMORY AT PRECEDING TIME?
YES
NO
SP7
NOTIFY HOST COMPUTER OF FAULT
SP9
IS HEAT GENERATION RESISTIVE ELEMENT 93RI LAST ELECTRIFIED HEAT GENERATING RESISTIVE ELEMENT 93RN?
NO
YES
END
SP18

FIG. 13

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(54) Head diagnosis apparatus and head diagnosis method for printer

(57) In a head diagnosis apparatus and the head diagnosis method for diagnosing the condition of a thermal head (1; 23), after measuring the resistance value of a plurality of heat generation resistive elements (93) arranged on a head surface of the thermal head, a change amount of the resistance value of each heat generation resistive element (93) is calculated on the basis of the resistance value of each heat generation resistive element (93) measured in the past and the resistance value of each heat generation resistive element (93) measured at the current time. An electrification state of each heat generation resistive element (93) is judged on the basis of the calculation result, and the thermal head (1; 23) is diagnosed to see whether it is good or bad in accordance with the determination result, thereby permitting the diagnosis on the condition of the thermal head (1; 23) before actually entering a printing stage.

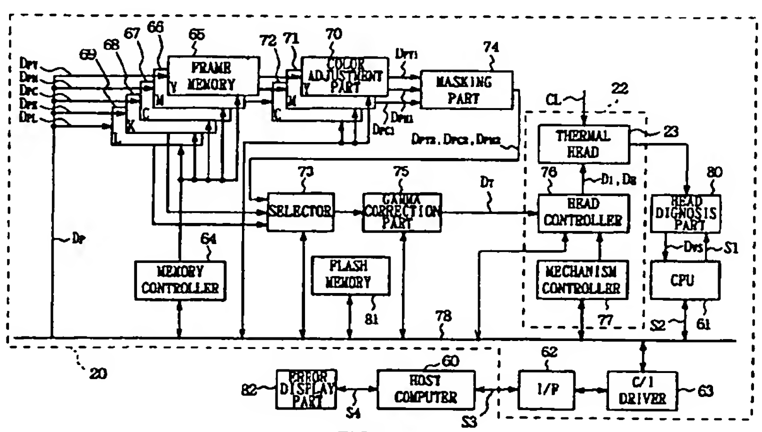

FIG. 7

EP 0 982 134 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 99 11 4794

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 546 112 A (HUNTER KEVIN D ET AL) 13 August 1996 (1996-08-13) * abstract * * column 4, line 15 - column 5, line 54 * * claims; figures *	1-14	B41J2/05 B41J2/35
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 334 (P-417), 27 December 1985 (1985-12-27) & JP 60 159662 A (TOKYO DENKI KK), 21 August 1985 (1985-08-21) * abstract *	1,2,4,5, 7-9, 11-13	
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A	US 5 469 068 A (KATSUMA NOBUO) 21 November 1995 (1995-11-21) * the whole document *	1-14	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	1 August 2000	Didenot, B

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